X. *Obſervations upon certain Fungi, which are Paraſitics of the Wheat. By the Rev. William Kirby, F. L. S.*

Read February 5, 1799.

DURING the time that my attention has been directed to thoſe inſects which frequent the wheat fields, I have often had occaſion to obſerve the appearances produced in that grain by ſeveral different ſpecies of *Fungi* (*a*), which derive their nouriſhment from it. I thought of conſidering this ſubject at large; but as my time is likely to be fully employed in other purſuits, I ſee no probability of doing this in the manner that I could wiſh; and therefore having made ſome obſervations, which, though by no means complete, may not be wholly unimportant, I now beg leave to lay them before the Linnean Society, truſting that they may ſerve as hints to others who may be inclined to enter more fully upon ſo intereſting a ſubject.

I have noticed five or ſix different ſpecies of theſe *Fungi*. The firſt I ſhall mention is named by Dr. Withering *Reticularia ſegetum* (*b*). In the Rev. Henry Bryant's pamphlet upon *Brand* (*c*), it is called

(*a*) That theſe appearances are produced by minute vegetables of the order of *Fungi*, ſeems now to be acknowledged by thoſe naturaliſts who are the moſt converſant with that order.

(*b*) Bot. Arr. vol. iv. p. 388.

(*c*) A particular Enquiry into the Cauſes of that Diſeaſe in the Wheat commonly called Brand, &c. Norwich 1783.

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Duſt Brand (*d*). Here its uſual name is *Smut* or *Burnt Corn.* This ſpecies is common to wheat, oats, barley, and rye. I have alſo ſeen *Feſtuca fluitans*, and ſome other graſſes, affected by it. It is ſcentleſs, and conſumes not only the farinaceous part of the grain, but even the arillus and chaff, diſperſing itſelf entirely before the corn is cut; ſo that the injury which it occaſions is confined to the quantity of grain deſtroyed by it, which is not very great in any ſeaſon. I have ſeen, more than once, half an ear of corn affected by this *Fungus*, when the other half was ſound and good. Sometimes it injures all the ſtems that ſpring from the ſame root; at other times part of them eſcape: I never could diſcover any diſeaſed appearance about the root. The ear is often affected by this *Reticularia* before it emerges from the *folium vaginans*, or *hoſe*.

Barley and oats are more frequently attacked by it than wheat; but this may be accounted for by the latter being uſually *dreſſed* for ſowing. Mr. Lathbury examined the duſt of this *Fungus* under a powerful magnifier, and found that it conſiſted of a number of minute particles, uniform in ſhape and ſize, much ſmaller and blacker than thoſe of the Pepper Brand, and leſs eaſily ſeparable: they ſeemed to be contained in little irregular cells. This duſt or ſeed is the food of a ſmall, ſhining, black *Dermeſtes* (*e*).

The next ſpecies that I ſhall mention is what Mr. Bryant diſtinguiſhes by the name of *Pepper Brand* (*f*); with our farmers it is ſimply called *Brand* or *Bladders.* This ſpecies does not eat through the arillus, conſuming only the farinaceous part of the grain. The ears affected by it are eaſily diſcovered by their external aſpect; for the chaff opens, as if unnaturally diſtended (*g*), the germen becomes ſhorter and rounder, and exhibits the appearance both of ſwelling

(*d*) Bryant, p. 31. 54—56. (*e*) *Dermeſtes ater.* Marſham. (*f*) Bryant, p. 32.

(*g*) Bryant, p. 43.

and (if it may be allowable to apply ſuch a term to it) inflammation; for, inſtead of the pale, pleaſant green which is the colour of this grain in a healthy ſtate, it aſſumes one of a deep and dingey hue: in this ſtate it eaſily breaks when rubbed; and the ſooty powder, that ſoils the fingers, emits a very fetid ſcent, extremely ſimilar to that of putrid fiſh or *Chenopodium Vulvaria*. Theſe circumſtances ſufficiently diſtinguiſh it from *Reticularia ſegetum*, and render it, when at all plentiful, exceedingly prejudicial to the farmer; for, as it does not eat its way through the arillus, and diſperſe itſelf before the corn is cut, it is carried with it into the barn, and, being broken under the flail, when the wheat is threſhed, diſcolours and otherwiſe injures the ſample, to ſuch a degree as to render it unſaleable, or at leaſt greatly to reduce its price. To prevent this evil, farmers generally dreſs their ſeed wheat with various preparations: ſome uſe a lixivium of wood aſhes and urine; others, ſalt and water only, or ſea water if at hand; others, the lie from the ſoap-boilers; others again, urine and cheeſe whey; and I have heard of ſome who have infuſed arſenic for this purpoſe. All, I believe, dry their ſeed with freſh ſlaked lime. This cuſtom, which is nearly univerſal, at leaſt in theſe eaſtern counties, proves the idea to be general, that the diſorder originates from the adheſion of the duſt or ſeed of the Brand to the ſeed of the wheat, and that by theſe methods it is either waſhed off or deſtroyed: but what kind of ſubſtance it is, whether animal, vegetable, or merely a diſtemper incident to this grain, agriculturiſts do not trouble themſelves much to inquire: this indeed is properly the buſineſs of the naturaliſt; and of theſe latter the opinions concerning it are various. Mr. Bryant, in the pamphlet referred to above, is ſtrenuous for its being occaſioned by an injury which he ſuppoſes the *antheræ* receive, by too great conſtriction, when the ear emerges from the *folium vaginans* (*b*); and therefore he ſcouts

(*b*) Bryant, p. 50—53.

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the common practice just mentioned of dressing the seed, as answering no good end, and destructive of the grain (*i*). Some take the dust for the eggs of insects, and others adopt, what to me appears the most probable opinion, that this evil is occasioned by a minute vegetable of the order of *Fungi*.

Mr. Bryant founds his hypothesis upon few experiments, and those not very precisely stated (*k*): the one was favourable rather than otherwise to the practice which he is endeavouring to set aside (*l*). This was made upon a small scale in his garden. From his larger experiment no fair consequences in support of either side of the question can be drawn; for it was made in two separate fields, the corn being sown unprepared in one, and dressed as usual in the other (*m*). Whether these fields were near to each other, or far asunder, or of a similar or different soil, he does not inform us. The result of this experiment was rather in favour (not much he confesses) (*n*) of the undressed seed. Now, as some years are much more favourable to the production of Brand, it is probable, than others (*o*), and it is not to be expected that any precaution should so infallibly secure our crops as that they shall never be injured, no sound reasoner would venture to build a system upon experiments, much more numerous and decisive than those related by Mr. Bryant, which were made in a single year. Again, as some soils may be more given to the production of this disease, or whatever we are

(*i*) In justice to this gentleman, I must acknowledge, that, with respect to this circumstance, his opinion seems founded upon fact; for I am informed by intelligent farmers, that much of the grain *does* perish, as they suspect, by the use of lime. But is the evil incurred, greater than the evil prevented?

(*k*) Bryant, p. 24, 25. (*l*) Id. p. 32, 33. (*m*) Id. p. 24, 25. (*n*) Id. p. 33.

(*o*) A tenant of mine, in the year 1797 I think, told me that his wheat that year was very much injured by the Brand, although he prepared it in the same manner as he had done for ten years before, and always till then with success.

to call it, than others, nothing ſatisfactory can be deduced from ſuch experiments as are tried in different fields, where the ſoil, aſpect, or mode of cultivation and management, might be different. Mr. Bryant's method of accounting for this diſorder is certainly ingenious, but founded upon no arguments which can convince one who is in ſearch not of theories but of truth. That the practice of dreſſing the ſeed previous to ſowing, in the way above mentioned, is a very effectual preventive of the Brand, will appear ſufficiently evident, when I proceed to lay before the Linnean Society the reſult of ſome experiments made by my ingenious and accurate friend the Rev. Peter Lathbury, F. L. S. Upon my informing him that I was going to put together a few obſervations upon the ſubject, he very obligingly allowed me the uſe of his memorandum-book, which alſo related another very deciſive experiment, upon a large ſcale, made by a gentleman of his acquaintance. It was in conſequence of reading Mr. Bryant's treatiſe that Mr. Lathbury and this gentleman made their experiments. To theſe I ſhall add a few inſtances, out of many, that have fallen within my own knowledge.

Mr. Lathbury procured two ſmall parcels of wheat, one from a clean ſample not at all infected by the Brand, and the other from one which it had much injured. Each parcel he divided into four equal portions, and prepared for ſowing as follows, dreſſing one portion from each parcel in the ſame manner. The firſt he waſhed carefully with ſpring water, and wiped with a ſoft dry cloth. The next he dipped in ſtrong white wine vinegar, and allowed to dry upon a ſheet of writing paper. A third he covered with ſalt water taken from the river; and after letting it remain in it for twelve hours, he wiped it as the firſt. The fourth portions were not dreſſed at all. The wheat from the clean ſample was planted on one ſide of his garden, and that from the branded one on another. When he

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ſowed the two undreſſed portions, before he covered the ſeed with earth he ſprinkled upon it ſome Brand duſt. The reſult of his experiment was, that the three firſt portions of both ſorts which had been prepared for ſowing were very little injured by the Brand. Thoſe which were from ſeed of the clean ſample had only one ear affected, and that partially. Thoſe from the branded ſample produced two ears that were partially branded, and three that were affected by the Smut or Duſt Brand (*Reticularia ſegetum*). But the produce of thoſe portions which had been ſprinkled with the duſt of the Pepper Brand was greatly injured by it, three-fourths of the grain being deſtroyed. There appeared no difference in the number of plants produced from each portion of the clean ſeed; every grain vegetated, except in one inſtance, where it was evident that thoſe which periſhed were deſtroyed by an inſect: but the number of plants produced from the injured ſeed was various; that which was waſhed with water produced the greateſt number, and that wetted with vinegar the ſmalleſt. Mr. Lathbury, in the dreſſing of the ſeed for his experiment, does not appear to have uſed lime; which I ſhould apprehend to be the moſt efficacious preventive of the evil, though at the ſame time it may probably be moſt deſtructive of the ſeed. Theſe portions of wheat were ſown at Orford on the 20th of September 1786.

The other experiment was made in the neighbourhood of Woodbridge in the following year. I ſhall give it in Mr. Lathbury's words: "Mr. John Woolnough of Boyton, a moſt intelligent and excellent farmer, read Mr. Bryant's pamphlet, and, in conſequence of his arguments, the next year ſowed a large field in alternate breadths with wheat taken from a good ſample (*without dreſſing*) and wheat that had been dreſſed in the uſual manner. Long before the corn was ripe, the difference was moſt diſtinguiſhable. Upon

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thoſe *ſtretches* (*p*) ſown with dreſſed wheat it was difficult to find any branded ears, except upon the edges, where it is probable the undreſſed had been occaſionally thrown in ſowing it by hand. The other breadths were ſo branded as to make it neceſſary for him to determine to carry the corn at ſeparate times to different places. A wet ſeaſon ſetting in, the hurry of buſineſs made him neglect this precaution; and being all houſed together, the whole crop, when threſhed out, was ſpoiled ſo much by the Brand duſt as to render the ſample unſaleable. He computed his loſs at 50l." I ſhall now copy an inſtance from Mr. Lathbury's memorandum-book, of miſchief incurred by a defect in the quality of the lime uſed for drying the ſeed: "Mr. Howlett of Blighborough Lodge, always accuſtomed to dreſs his wheat with ſalt water and freſh ſlaked lime, was induced, from the magnitude of his concern, to purchaſe a quantity of lime which from ſome circumſtances was offered to him at a much leſs price than uſual. When he dreſſed his wheat with it, it was *air-ſlaked*, but did not appear otherwiſe altered by keeping; yet had it ſo far loſt its ſtrength, that his crop that year was injured by the Pepper Brand to the amount of upwards of 300l. in the opinion of good and able judges." Thus far Mr. Lathbury's communications.

I ſhall now proceed, as I propoſed, in the next place to mention ſome inſtances which fell within my own knowledge. Laſt year an intelligent farmer informed me, that through haſte he had neglected to dreſs part of his ſeed wheat, and that in conſequence of it the crop of the field where it was ſown was greatly injured by the Brand, while the reſt of his wheat was free from it. He alſo informed me, that if old wheat was uſed for ſeed, it was not ſubject to it. During

(*p*) I know not the orthography of this word. It is uſually pronounced *ſletches*. It is the name given to thoſe breadths, narrower or wider according to the nature of the ſoil, into which a field is divided previous to ſowing.

the preſent year, a gentleman who occupies a conſiderable tract of land in the pariſh of Barham, and who is very attentive to farming, told me, that in a particular field, the dreſſed ſeed not holding out, they ſowed the headland with what was undreſſed. The conſequence was, that this part was very full of the Pepper Brand, while the reſt of the field eſcaped. Another gentleman, who was brought up in the medical line, but has now taken to farming, aſſures me, that ſince he has dreſſed his wheat he has never ſuffered from this evil; and ſo convinced is he of the efficacy of the common method, that he is determined to prepare barley and oats in the ſame way, in order to prevent the *Duſt* Brand. I could multiply more inſtances, if neceſſary, from information received from other quarters; but I think theſe are fully ſufficient to prove that Mr. Bryant's hypotheſis is not founded upon facts. It ſeems evident from them, that the miſchief is carried with the ſeed into the field (*q*), and that the uſual mode of dreſſing it acts as a ſufficient preventive. From one of Mr. Lath-

(*q*) It may be objected here, that ſeed wheat is always taken from a clean ſample, and that therefore it is moſt probable that it ſhould meet with the ſeeds of the Brand in the ſoil; but in that caſe how could the previous dreſſing, eſpecially a ſingle waſhing, act as a preventive? Old ſeed, we ſee, is not ſubject to it; which muſt, I ſhould think, ariſe either from the Brand Duſt being rubbed off by the frequent friction of the grains one againſt another, when turned over, or from the latter loſing its vegetative principle: but neither of theſe circumſtances would hinder its attack, if the Brand Duſt were already in the ſoil. Beſides, its remaining within the grain, and not like the *Duſt Brand* eating through the arillus, militates ſtrongly againſt ſuch a ſuppoſition. It is probable that in every wheat field a few ſcattered ears may be branded, and theſe would be ſufficient to infect a large parcel of grain; for every diſeaſed kernel contains millions of ſeeds of the Brand, and the frequent turning over and mixing of the corn would diſſeminate theſe through a conſiderable quantity. Still I would not be underſtood to aſſert, that Brand left in the ſoil never attacks the wheat: ſuch a circumſtance may account for its prevalence in ſome ſeaſons, even where corn has been dreſſed: all I contend for is, that this is not uſually the caſe.

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bury's experiments it appears, that the ſimple waſhing of the ſeed with water, if it be carefully wiped, anſwers all the end of ſteeping in a more expenſive preparation. This perhaps could not be done with ſufficient care and accuracy upon a large ſcale, otherwiſe the moſt ſimple and leaſt expenſive method is certainly the beſt, and all that ſeems to be wanted previous to ſowing is thoroughly to cleanſe the ſeed from the Brand duſt that adheres to it. Probably wetting the ſeed with water, and afterwards drying it with freſh ſlaked lime, would anſwer every purpoſe.

The ſuppoſition that the Brand is produced by inſects is not ſupported by one fact or experiment that I have ever heard of: indeed, the ſingle circumſtance that the diſorder originates with the ſeed, and from thence paſſes by ſome unknown channel into the plant, entirely overturns it. I ſhall not therefore loſe time by dwelling upon it, but proceed further to eſtabliſh the third opinion, that the diſorder is occaſioned by a vegetable ſubſtance. The fact eſtabliſhed by the above experiments, that the duſt of Brand, carried into the field with the ſeed wheat, like other vegetables propagates itſelf, gives the higheſt degree of probability to this opinion; which is ſtill further confirmed by the reſult of Mr. Lathbury's experiment of ſowing it as it were upon its native ſoil (eſpecially in the caſe of wheat taken from a clean ſample), which ſeems to have occaſioned the deſtruction of three-fourths of its produce. This is as deciſive a proof as can be deſired of its being a vegetable. But what I think places the matter beyond all doubt, is that this duſt, when put under a powerful magnifier, exhibits every appearance of minute ſeed. I happened to take ſome duſt from branded grains, I think laſt year, which I laid by for future inſpection. After I had begun this Paper, I ſtrewed ſome of that duſt upon a piece of glaſs; and putting it under a very ſtrong magnifier over a reflector, I was highly gratified

fied with observing that every particle of Brand was a globular seed; not the least variation in shape or magnitude was visible amongst them. I afterwards put a drop of water upon them, and let them remain in this situation for some time; but it produced no alteration whatsoever in their appearance. I afterwards examined in the same way the dust of one of the stellated *Lycoperdons* which I happened to have by me; but the particles of this were much smaller than those of the Brand, and not of a form so visibly determinate. Mr. Lathbury also tried a variety of experiments with the same view; and in every one "the dust when diluted with water instantly separated, and presented to the eye invariably a number of globules, touching each other, alike in form and size."

It now remains for consideration, how these seeds vegetate and ascend from the seed with the growing plant till they reach the heart of the grain. This is an inquiry that may be extended to a great number of the *Fungi*, which without impropriety may be denominated *subcutaneous* vegetables: for instance, the several species of *Æcidium* (for they are numerous), *Uredo* (*r*), and not a few *Sphæriæ*, except that these latter grow upon decaying substances: but these I shall let alone, and only offer a conjecture, for it is merely such, with respect to the Brand. Perhaps then the uncommonly minute seeds of this *Fungus* may attach themselves either to the *plumula*, and so pass through the air vessels into the plant; or else to the *rostellum*, which to me seems most probable; and in that case they may be propelled through the sap vessels with the sap, till at length they arrive at their final seat, the heart of the germen. Whether this species belong to the genus *Reticularia* or not, I must leave to be determined by those gentlemen who are more deeply skilled in "*cryptogamic lore*" than I am.

(*r*) Are *Æcidium* and *Uredo* sufficiently distinct?

The next *Fungus* of the wheat that I ſhall notice, is that *Ædidium* known to agriculturiſts by the name of the *Red Gum*. This ſpecies grows uſually upon the inſide of the glumes of the calyx and of the exterior valvule of the corolla, under their *epidermis*; which, when the plant is ripe, burſts, and emits a powder of a bright orange colour. This little plant, which is now well known (*s*), does not appear to be materially injurious to the grain, if at all. I have ſeen ears full of it, with very plump kernels. I have alſo found it upon branded ears. Before the cuticle which covers the ſeed of this *Fungus* burſts, it has very much the appearance of a ſmall puſtule upon the human body.

Another plant of this order, which is very common upon wheat, is that named by Mr. Lambert in the Linnean Tranſactions (*t*), and by Mr. Sowerby in his elegant work upon Engliſh Fungi (*v*), *Uredo Frumenti*. It grows upon the foliage, culm, and glumes, burſting in longitudinal ſtreaks from under the *epidermis*. Theſe gentlemen repreſent this plant as the *blight* of the wheat, which in certain ſeaſons and ſoils is ſo injurious to that grain. I had myſelf for ſome time ſuſpected that it was the cauſe of that diſeaſe; but after repeated examination of ears the ſtraw of which was quite black with it, I had given up that opinion, for in no one inſtance was the grain injured by it. Yet I would by no means be underſtood to contradict the aſſertion of theſe gentlemen *in totum*. This plant, when it makes its attack before the wheat begins to harden, by depriving it of part of its nutriment may occaſion it to ſhrink; and Mr. Lambert's own experience ſeems to confirm this obſervation: unleſs the miſchievous plant which I ſhall next mention had taken poſſeſſion of the ear, at the ſame time that the *Uredo Frumenti* had diſcoloured the ſtalk;

(*s*) *Linn. Tranſ.* vol. iii. p. 249, 250.
(*t*) Id. vol. iv. p. 193, 194.
(*v*) *Engliſh Fungi*, vol. ii. tab. CXL.

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for the ſame circumſtances would be favourable to the production of both, although we have reaſon to be thankful that the latter is much the moſt common of the two. I doubt not but theſe gentlemen will readily excuſe my diſſent from their ſentiments in this inſtance; and ſhould future examination prove me in the wrong, I ſhall with pleaſure retract. In ſubjects not thoroughly diſcuſſed and underſtood, the colliſion of opinions contributes very much to bring hidden truths to light.

In the year 1797 the wheat ſuffered much by the *blight*, or *mildew* as our farmers more commonly call it, by far the worſt enemy of that grain; and I had frequent opportunities of examining into the cauſe of it. The ears that were injured by it were to be diſtinguiſhed at a conſiderable diſtance by their blackneſs; and when brought cloſe to the eye, they appeared as if ſoot, or ſome other ſmutty powder, had been ſtrewed over them. Under a common lens (for at that time I had no other) the chaff appeared covered with ſmall black dots irregularly ſcattered over it, and widely different from the appearance of *Uredo Frumenti* upon the ſame part, which is very accurately repreſented in Mr. Sowerby's figure. Whenever this appearance ſeizes an ear, it invariably occaſions the grain to ſhrink ſo much as to be fit for nothing but to feed hogs or poultry. I do not recollect making any obſervations upon the ſtate of the ſtraw; but I have a memorandum, made in a field from which I took many ears, which ſays that the ſtraw of the mildewed wheat in that field was clean; and if my memory does not fail me, the mildew itſelf was always confined to the ear; though ſometimes the ſtraw might be affected, as I hinted above, by *Uredo Frumenti* at the ſame time. Some farmers, whom I have conſulted, have told me that the ſtraw is always injured; but others have confirmed my own obſervation in the field above mentioned, that it is not invariably ſo. I ſhould obſerve, that the foliage

of the mildewed wheat in this field was diſtinguiſhed by another ſpecies of *Uredo*; though perhaps this might be only another appearance of the mildew, which diſcharged its ſeed at regular intervals in dots. From the abſence of *Uredo Frumenti* in this inſtance, it is evident that the mildew is independent of that plant, and ſo *vice versâ*. A whole diſtrict in the neighbourhood of Barham is particularly given to this evil; but improved management of the ſoil, I am told, will ſerve as a remedy. The appearance occaſioned by the mildew, upon an ear examined under a lens, did not ſo fully convince me of its being a *Fungus*, as that of the four preceding ſpecies; the dots were too minute to determine with certainty without a more powerful magnifier: yet I am moſt inclined to that opinion; and it derives additional force from what was once related to me by a gentleman who had been abroad, that an Italian Abbate, I forget who, had written a memoir upon the ſubject, in which he had proved the mildew to be a very minute *Lycoperdon*. He promiſed to ſend me the pamphlet, but was not ſo good as his word. The preſent year produced no mildew, that I can learn; and I ſent my ſpecimens to Mr. Sowerby.

I have now brought to a concluſion what I had to ſay upon thoſe paraſitic *Fungi* which I have obſerved upon the wheat; and I hope that theſe hints, for ſuch only I deſire that they may be conſidered, may induce other gentlemen, more deeply ſkilled in this department of natural hiſtory than I am, to purſue them further. The ſubject, if viewed as cloſely connected with agriculture, is certainly important; and if the ſtudy of it ſhould lead to a diſcovery of a method of preventing the *Blight*, as effectual as that which has long been uſed by farmers to ſecure their crops from the *Brand*, the naturaliſt who led the way to it would have no reaſon to think that his labours were in vain.

Much has been done in this country towards inveſtigating the *Fungi*

Fungi by Meſſ. Withering, Woodward, Dickſon, Bolton, Sowerby, &c. yet the knowledge of this claſs of vegetables is *adhuc in incunabulis,* and many years muſt elapſe before we may expect to ſee it upon the ſame firm footing with the other branches of botany. There is ſcarcely a leaf (at leaſt of trees and ſhrubs) falls to the ground, that has not its peculiar *Fungus*, which, aſſiſted by humidity, reduces it to its original earth. The ſame obſervation may be extended to ſticks (*w*) and ſtalks, and many other ſubſtances. The more we attend to theſe things, the further we ſhall ſee into the plan of Divine Providence, and, every ſtep we take, be more and more convinced that there is nothing either deficient or ſuperfluous; but that all things are created in weight and meaſure, and work together (whether their office be to preſerve or to deſtroy) to promote the beſt ends by the moſt efficacious means.

(*w*) Mr. Sowerby, in his *Engliſh Fungi* (vol. ii. tab. cxxxvii), has given the name of *decorticata* to a particular ſpecies of *Sphæria*, as ſuggeſted by me, probably owing to my bad writing. The name I intended was *decorticans*, from the circumſtance of its growing under the bark, and finally occaſioning it to peel off.

XI. *Ca-*